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# PROCEEDINGS OF THE REGIONAL SYMPOSIUM ON RECENT ADVANCES IN MASS CLONAL MULTIPLICATION OF FOREST TREES FOR PLANTATION PROGRAMMES

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1 - 8 December 1992  
Cisarua, Bogor, Indonesia

Edited by John Davidson



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UNDP/FAO Regional Project on Improved Productivity of  
Man-Made Forests Through Application of Technological  
Advances in Tree Breeding and Propagation (FORTIP)

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PRODUCTIVITY OF MAN-MADE FORESTS THROUGH  
APPLICATION OF TECHNOLOGICAL ADVANCES IN  
TREE BREEDING AND PROPAGATION (FORTIP)**



## CURRENT ADVANCES IN CLONAL PROPAGATION METHODS OF SOME INDIGENOUS TIMBER SPECIES IN SABAH (MALAYSIA)

O. Monteuuis<sup>1</sup>

### ABSTRACT

*Octomeles sumatrana*, *Anthocephalus chinensis* and *Endospermum peltatum* are potentially very attractive light hardwood timber species for South-East Asia from which they originate. Owing to their characteristics, cloning seems obviously the best option for large-scale reforestation operations. The first experiments carried out established the possibility to restore within a short time period the original ability of the mature selected ortets to be true-to-type propagated through rooted cuttings, providing that suitable methods are used. In this respect, the serial vegetative propagation techniques tested proved to be quite efficient, leading from the second generation of stock plants to scores compatible with mass production of high fidelity cloned rooted cuttings. These results are discussed mostly from a pragmatic point of view in terms of maturation and possible rejuvenation in relation to cloning.

**Key words:** Adventitious rooting, *Anthocephalus chinensis*, true-to-type cloning, *Endospermum peltatum*, *Octomeles sumatrana*, vegetative propagation.

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## 1. INTRODUCTION

Sabah, located in the northern part of Borneo, is one of the 13 states that constitute the Federation of Malaysia.

About 51 percent of its total area, that is to say 37 000 km<sup>2</sup> out of 73 711 km<sup>2</sup>, are covered by high value forests. This accounts for the leading position of the timber industry in the economy of the country, mostly based on the export of natural resources. However, such intensive timber exploitation has resulted in severe depletion of stocks to the point that there is an urgent need to renew the timber resources by intensifying reforestation efforts adapted to the local context. In this situation, indigenous forest tree species such as *Octomeles sumatrana*, *Anthocephalus chinensis* and *Endospermum peltatum*, owing to their attractive characteristics, merit special consideration to fulfill the purpose in view.

## 2. MAIN CHARACTERISTICS OF *OCTOMELES SUMATRANA*, *ANTHOCEPHALUS CHINENSIS* AND *ENDOSPERMUM PELTATUM*

*Octomeles sumatrana*, belonging to the Datisceae family and commonly named "Binuang", occurs from Sumatra to Papua New Guinea and the Solomons, and northwards to the Philippines, but, curiously, is missing from Peninsular Malaysia.

It is a large and vigorous tree reaching 35 to 40 m in height with a clear bole of 20 m or more and girth sometimes exceeding 6 m. Although growing best on rich alluvial soils near rivers, it can thrive quite well in somewhat hilly areas. The form is generally good, but is often heavily buttressed, depending on the individuals.

The seeds produced by this monoecious species are tiny (4 to 7 millions of seeds per kg) and must be collected by climbing before the fruits mature to improve the natural germination ability.

*Octomeles sumatrana* produces a light coloured wood with a density ranging from 270 to 465 kg/m<sup>3</sup> for which uses include plywood, light construction, backs of furniture and most probably also chipboard.

*Anthocephalus chinensis* (Rubiaceae), synonymous with *A. cadamba*, is commonly called "Laran" in Sabah, "Kelempayan" in Peninsular Malaysia, "Kelempajan" in Indonesia and "Kaatoan Bangkal" in the Philippines.

This common fast-growing pioneer with an height ranging from 20 to 40m exhibits a typical silhouette with very characteristic horizontal branches located only in the upper part of the tree as the result of a good self pruning ability. It can be easily found in secondary forests throughout South East Asia, mainly along old logging roads and abandoned landings.

*Anthocephalus chinensis* is a monoecious species producing small seeds which need to be extracted from the fruits and cleaned carefully several times before sowing to improve the germination rate, which is usually low.

The wood is white-yellow with an average density of 370-465 kg/m<sup>3</sup>. It is suitable for pulping (Burgess 1966) or for other uses such as packing cases, toy-making, temporary constructions and even wooden shoes ("terompak").

*Endospermum peltatum* (Euphorbiaceae) is locally named "Sendok Sendok" in Sabah, "Sesendok" in Peninsular Malaysia and "Gubas" in the Philippines.

This medium-sized tree species, reaching 25 to 30 m in high, occurs more in secondary forest, after logging and clear felling.

The seeds of this dioecious species display a deep dormancy and are very often destroyed by natural predators.

The rather bright yellow soft wood produced, with a density varying from 305 to 655 kg/m<sup>3</sup> is suitable for different utilizations such as temporary constructions or interior joinery. Because of its sensitivity to damage by borers, it needs to be impregnated for exterior joinery and cladding.

To sum up *Octomeles sumatrana*, *Anthocephalus chinensis* and *Endospermum peltatum* are considered as potentially attractive timber species for reforestation operations in South East Asia by virtue of the following qualities:

- \* they are indigenous species well-adapted to a wide range of local site conditions;
- \* they are natural pioneer species, displaying early vigour and fast growth in clear stands like logged areas and secondary forest;
- \* they have been recognized as light hardwood timbers due to the quality of the wood produced in a reasonably short time, which is adapted to many and various uses.

However, their propagation by seed remains problematic, because fruiting is irregular and the seeds are difficult to collect and store.

### 3. INTEREST OF THE CLONAL PROPAGATION OPTION APPLIED TO THESE SPECIES

Apart from any genetic aspect consideration, cloning, based on the utilization of vegetative propagation methods exclusively, is indeed a means to multiply trees. This constitutes a major argument when there are limitations of propagation by seeds to fulfill certain objectives, as it is obviously the case for *Octomeles sumatrana*, *Anthocephalus chinensis* and *Endospermum peltatum* in view of establishing large-scale plantations that require big quantities of planting stock.

Additionally to this aspect strictly restricted to the multiplication rate, the basic feature of cloning by contrast with sexual propagation through seeds consists, throughout mitosis and only mitosis, in duplicating the selected individual - the ortet - while preserving its whole genetic identity and structure. This means in term of plant improvement, capturing and transferring to the vegetatively obtained offspring the integral genetic value - both additive and non-additive components - of the ortet they derived from. This is of paramount importance as variations due to such non-additive gene effects can exceed 50 percent in forest tree species (Hasnain and Cheliak 1986), affecting especially major traits such as form, vigour and wood characteristics, which are known to be under polygenic control and not so well inherited sexually.



More specifically, despite the overall good quality of the natural stands of *Octomeles sumatrana*, *Anthocephalus chinensis* and *Endospermum peltatum* regarding these traits, some noticeable individual differences have been observed, including wood density variations, that should warrant clonal propagation.

As the first step, rigorous multi-site clonal tests will permit, firstly an assessment of the influence of site effects on the selected genotypes, and secondly to refine the clonal selection by comparing the different clones initially selected upon phenotypic criteria of the ortet. The superior genotypes finally retained will constitute the cloning plant material for large-scale clonal plantations, assuming effective vegetative propagation methods are available to take full advantage of the clonal option.

The theoretically higher genetic gain connected with cloning remains in practice closely dependent on the efficiency of the vegetative propagation techniques to clone true-to-type the selected individuals, taking into account their specific characteristics. This aspect, owing to its decisive impact in view of clonal plantations, has been investigated for the three indigenous species previously mentioned, for which there is lack of relevant information.

## 4. EXPERIMENTAL RESULTS

### 4.1. General Information Regarding the Procedures Used

As soon as the shoots had been collected from the donor plant, cuttings were made, distinguishing between the terminal shoot ones with the apical bud, and the "single-node" ones consisting of one single node plus the internode underneath up to 10 cm for the total length. For some experiments, the original position of each cutting within the shoot was noted sequentially with the terminal shoot cutting as "order 1", the single-node cutting immediately below as "order 2",... and so on down to "order 4". About 50 to 70 percent of the leaf surface of the node cuttings were removed to lower the evapo-transpiration rate, and also to reduce hydric stress risks. Auxinic treatment consisted of dipping the base of the cutting into a commercial powder

preparation. "Trihormone" (3 % of naphthaleneacetic acid), "Seradix 2" (0.3 % of indole-3-butyric acid) and a so-called "Mixture" of Trihormone and Seradix 2 (1/1, w/w) were used; untreated cuttings served as control.

Once made, the cuttings were inserted into the rooting beds filled with wet sand used as rooting substrate after it had been boiled to reduce disease risks (Hartmann *et al.* 1990).

The experimental design most frequently adopted for assessing the effect of the investigated factors corresponded to a full-factorial type with totally randomized elementary plots regrouping a fixed number of cuttings - 10 replicates or more depending on the experiment.

The environmental conditions consisted of 50 percent shade with intermittent-mist water sprays provided by a mist-system whose frequency was controlled by the so-called "electronic leaf" system (Hartmann *et al.* 1990) to avoid any desiccation damage. Aqueous fungicide solutions - mainly "Thiram 80" at 5g/l - were sprayed on the cuttings once a week.

Capacity for adventitious rhizogenesis was examined after a rooting period of 2 months in these conditions by recording the following criteria:

- i. percentage of surviving and rooted cuttings out of the amount initially set;
- ii. number of adventitious roots per rooted cutting;
- iii. root score, according to Struve and McKeand (1990) definition: "dividing the cross-sectional area of each rooted cutting base into quadrants, the longest root in quadrant 1 was assigned 1 point toward the root score; any additional roots in quadrant 1 were each assigned 0.25 point, whereas those in quadrants 2 or 4 were assigned 0.5 point and those in quadrant 3 were assigned 0.75 point".
- iv. length of the longest root (in cm) neoformed per rooted cutting.

Statistical analyses were made using SPSS/PC+ statistical package.



#### 4.2. Obtaining the First Generation of Vegetative Copies From the Ortet

Production of the first generation of vegetative (= genetic) copies from a mature ortet is usually truly recognized as a critical step known as "mobilization phase", and upon which depends the subsequent steps of a successful cloning programme.

The mature selected ortets - over 20 year-old or more as estimated age - of the three indigenous species studied, namely *Octomeles sumatrana*, *Anthocephalus chinensis* and *Endospermum peltatum* were just cut down by chain saw at about 1m high from the base, regardless the time of the year, since climatic seasonal variation is slight.

The great majority of the stumps sprouted within 1 to 3 months, depending on the species and on the individuals, to produce soft and succulent elongating shoots.

These needed to be sufficiently, but not too much developed to be considered as the most promising material. Too vigorous shoots with over-differentiated tissues induced high mortality rates of cuttings and topophysis effects for the rare ones that rooted. This was particularly true for *Anthocephalus chinensis* in which vigorous shoots emerging from the stump displayed very early a predominance of horizontal branches. Trying to root ramets from this kind of plant material led to 92 percent mortality and the few rooted cuttings demonstrated a very well pronounced and symptomatic "branch-like" growth habit. By contrast, repeating the same experiment from less developed sprouting shoots reduced the mortality rate to 35 percent with an overall rooting rate of 63 percent and the possibility of restoring the desired orthotropic growth habit.

So, the development stage of the shoots produced by the stump from which the cuttings were made appeared to be a determining factor for optimizing the mobilization phase of propagation. The best plant material produced by the stump seemed to be 20 to 30 cm long orthotropic extending shoots, with not yet fully elongated internodes.

In fact, the more frequent the visits to the stumps *in situ*, the more chances to collect the ramets at the most suitable stage, for the time required to produce such desirable plant material was observed to vary:

- according to the species; as an indication, in our local conditions, the first plant material collections were performed 3 months on average after the ortet had been cut down for *Octomeles sumatrana*.
- from one individual to another within the same species;
- within one stump.

Moreover, the stumps were observed to be able to produce several successive generations of sprouting shoots before giving out. This ability could be stimulated by leaving intact at least one shoot per collected stump, and, when possible, the basal portion of the elongating shoots removed, thus stimulating the production of new additional axillary shoots arising from this part.

Using the best plant material from the stumps, the effects of different experimental factors on the ability of the ramets to form an adventitious root system were investigated:

#### 4.2.1. Genotypic influence

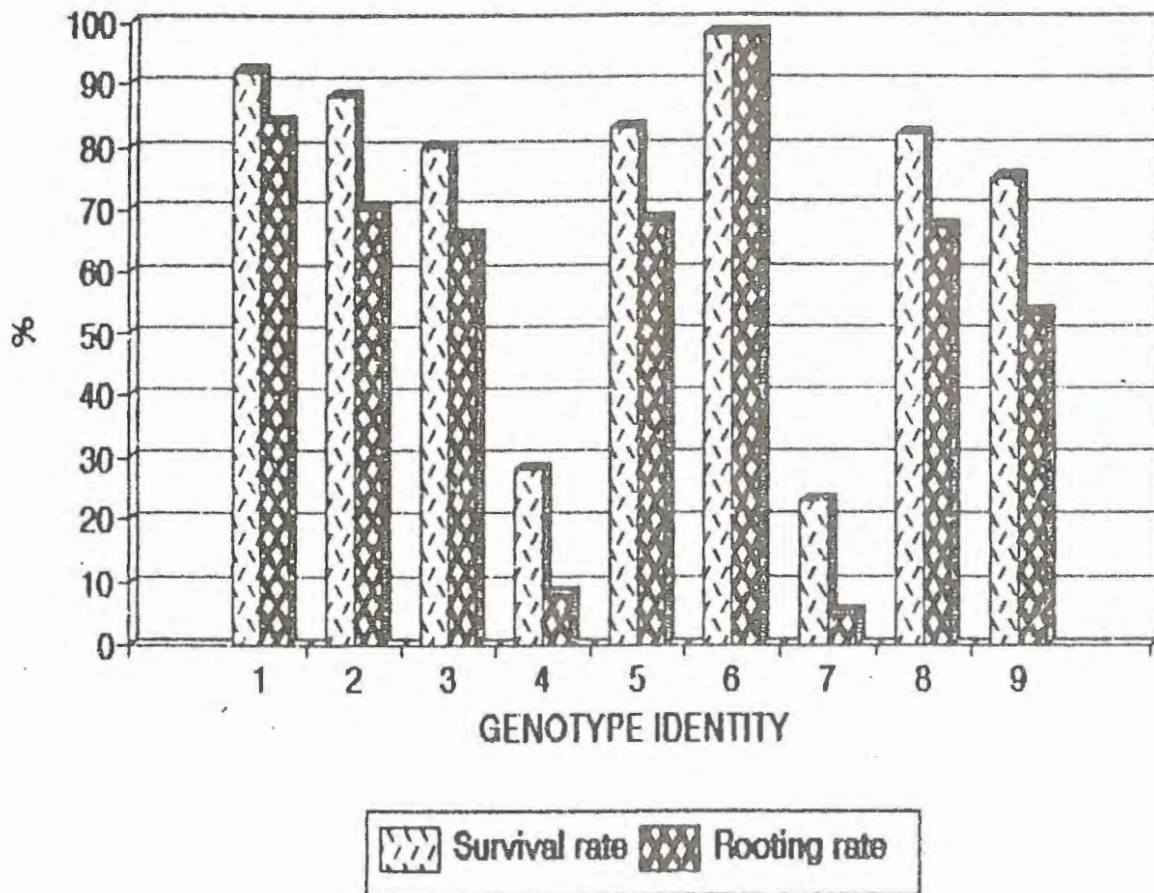
The influence of the genetic identity of the selected ortet on the potential for adventitious rooting of its ramets was especially examined on *Anthocephalus chinensis*, for which a significant genotypic effect ( $P < 0.01$ ) was found on the survival rate and rooting rate, as illustrated in Figure 1. It should be mentioned however that this evaluation was restricted to only one collection date.

#### 4.2.2. Auxinic treatment influence

The adventitious rooting capacity of single-node cuttings - orders 2 and 3 - of *Octomeles sumatrana* and *Endospermum peltatum* was shown to be significantly ( $P < 0.01$ ) stimulated when treating the base of the ramets with auxins, with varying results in terms of rooting scores however depending on the preparation used, as reported in Table 1 for *Octomeles sumatrana*.

By contrast, no significant beneficial effect of exogenous auxin (Mixture) was found for *Anthocephalus chinensis* ramets, either in terms of overall rooting rates, or with respect to the qualitative criteria assessed (see Fig. 2 a-d), except for the average measurement of the longest neoformed root ( $P = 0.02$ ).

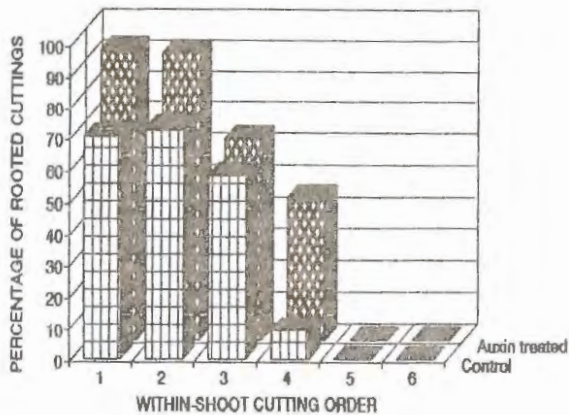
**Figure 1. Genotypic influence on survival and rooting rates of the first generation of *Anthocephalus chinensis* cuttings.**



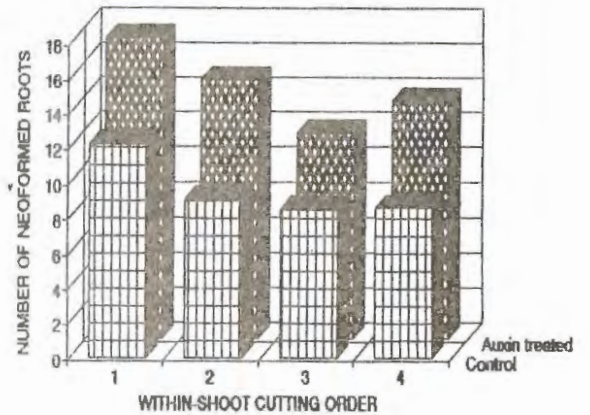


**Figures 2 a-d. Auxin treatment (Mixture) and within-shoot position effects on the different criteria assessed to evaluate the capacity for adventitious rooting of the first generation of *Anthocephalus chinensis* cuttings.**

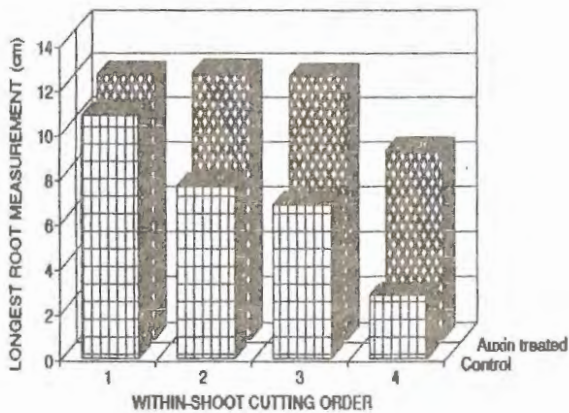
**2a. Auxin treatment and within-shoot position effects on rooting rates**



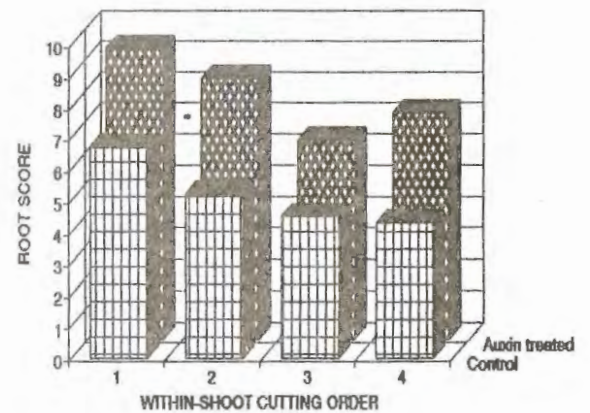
**2b. Auxin treatment and within-shoot position effects on number of roots**



**2c. Auxin treatment and within-shoot position effects on root length**



**2d. Auxin treatment and within-shoot position effects on root score**



**Table 1. Effect of different auxinic treatments on the capacity for adventitious rooting of the first generation of single-node cuttings of *Octomeles sumatrana*.**

| AUXIN             | Rooting Rate (%) | Root number | Longest root (cm) |
|-------------------|------------------|-------------|-------------------|
| Without (Control) | 23.3             | 1.4         | 6.0               |
| Seradix 2         | 26.9             | 3.4         | 9.5               |
| Trihormone        | 42.4             | 6.8         | 12.8              |
| Mixture           | 86.4             | 18.9        | 14.9              |

### **3. Influence of the original position of the cutting within the shoot *in situ***

For both *Octomeles sumatrana* and *Endospermum peltatum*, terminal shoot cuttings - order 1 - were found to be much more affected by mortality - up to an average rate of 95 percent - than the single-node ones located just underneath in the shoot *in situ* - orders 2 and 3. These latter showed the highest survival rates and the best ability for adventitious rooting with rooting rates ranging between 35 to 45 percent for the two species. It should be noticed that more basal segments like "order 4" demonstrated lower potential for survival and adventitious rooting too.

In the case of *Anthocephalus chinensis*, a gradient of mortality connected to the original position of the cutting within the shoot ( $P = 0.03$ ) and increasing from the top to the base origins was established with a big survival rate drop affecting the orders 3 and 4 - attenuated however by the use of the exogenous auxin (Mixture) - to reach 0 percent for the orders 5 and 6.

The potential for adventitious rooting followed a similar trend as illustrated in Figure 2, all the criteria assessed being significantly affected by the "within-shoot" initial position of the cutting ( $P < 0.05$ ), in the absence of any significant interaction with the auxinic treatment.



Surprisingly, and by contrast with the two previous species, the terminal shoot cuttings were shown to react quite well.

To sum up, "mobilizing" mature genotypes of *Octomeles sumatrana*, *Anthocephalus chinensis* and *Endospermum peltatum* through rooted cuttings collected from sprouting stumps once the ortet had been cut down appeared to be quite feasible in most cases, providing that:

- \* special care was taken to choose the best plant material emerging from the stump;
- \* these were made while limiting the stress and in agreement with the usual recommendations (Hartmann *et al.* 1990), and sufficiently sophisticated rooting facilities were available, especially as regards the mist-system.

The first generation of cuttings was observed nevertheless to display noticeable and unsuitable heterogeneity in terms of overall response for adventitious rooting capacity, as reported for several traits examined.

Moreover, once potted, the first generation of rooted cuttings showed variable vigor and growth rate, and a substantial number of them, particularly for *Anthocephalus chinensis*, still displayed abnormal growth pattern, probably due to topophytic effects.

Such behaviour could be most likely interpreted as resulting from persistent effects of the mature physiological condition of the original ortet the cuttings came from (Franclet 1985, Monteuis *et al.* 1987).

Appropriate stock plant management has been reported to reduce such negative effects of maturation on the ability for true-to-type cloning (Franclet 1977, Monteuis and Bailly 1987, Monteuis *et al.* 1987). This was tested on the first generation of rooted cuttings obtained.



### 4.3. Effects of Serial Propagation Methods to Enhance the Ability for True-to-type Cloning of the Mature Selected plant Material

The current concepts of stock plant management fall into two major categories:

1. hedged well-established outdoors stock plants to maintain a low bush-like form to produce suitable material to make cuttings collected several times over years; this procedure has been utilized with success for many years and could be considered therefore as the most classical (Hartmann *et al.* 1990).
2. serial propagation in which the rooted cuttings that constitute the current (n) generation were collected from the former (n-1) generation and will provide the cuttings for the next (n+1) generation. Usually, only one collection of cuttings is performed on each generation of rooted cuttings which are kept intensively cultivated in the nursery, sometimes in pots filled of appropriated substrate, before being used as planting stocks. Rooted cuttings managed in such a way cumulate thus two functions (Monteuuis *et al.* 1987).

A third possible strategy consists in combining these two procedures, giving rise to a serial propagation scheme in which each generation of potted cuttings is harvested several times, depending on the vigour of the plants and any ulterior utilisation, as planting stock for instance.

These three concepts of stock plant management are illustrated in Fig. 3.

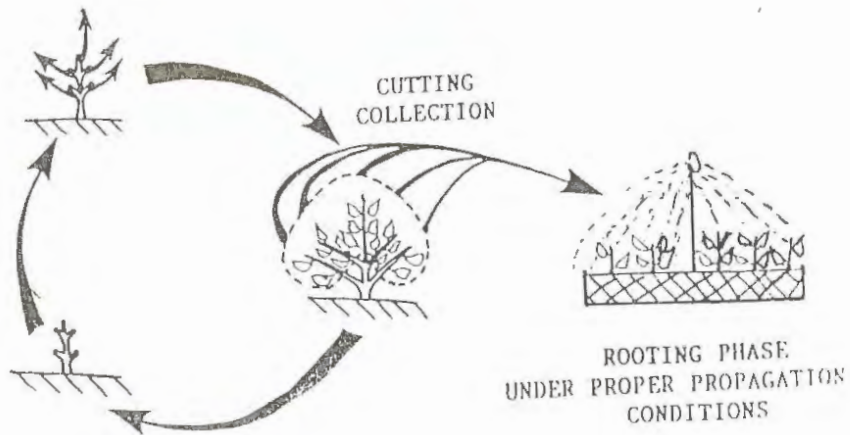
The serial propagation concept, either in its original form - option 2 - or combined with reiterated hedging, or more advisedly pinching due to the characteristics of the plant material, - option 3 - was used for our experiments. *Octomeles sumatrana* was more particularly studied.

Once rooted, the cuttings had been potted in 2l plastic bags., filled with local top soil, and kept intensively cultivated - "forced" - using liquid complete fertilizers under shade for the few weeks required to produce the cuttings for the next propagation cycle.

**Figures 3. Schematic representations of different donor plant management concepts.**

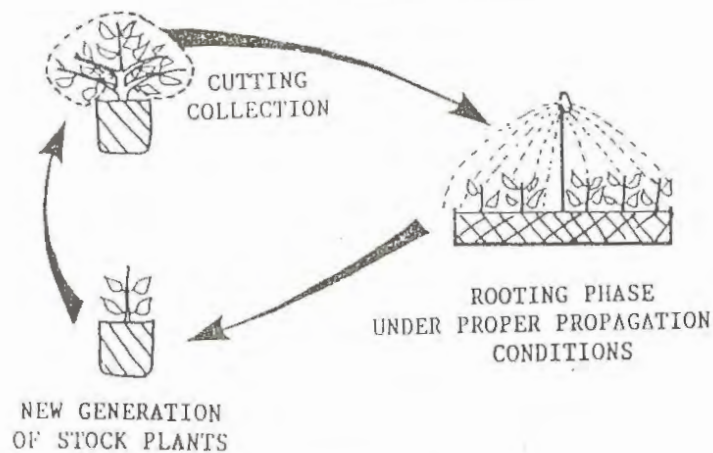
OPTION 1

USUAL STOCK PLANT CONCEPT



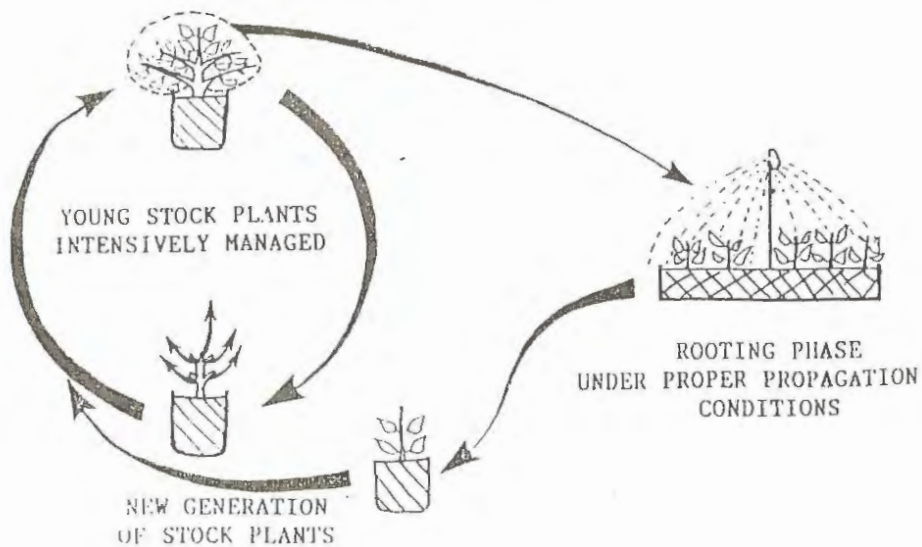
OPTION 2

SERIAL PROPAGATION CONCEPT



OPTION 3

COMBINING THE TWO CONCEPTS



Increasing the manipulations starting from the first generation of rooted and potted cuttings - which can be considered and referred to as stock plants therefore - gave rise to two fundamental remarks:

1. Contrary to the "mobilization phase" (G1), the terminal shoot cuttings appeared from the second generation (G2) onwards to be the best plant material for true-to-type cloning, with overall rooting rates ranging between 90 and 100 percent, and 15 to 20 neoformed primary roots on average per rooted cutting (see Fig. 4).

At the same time, the influence of the "within-shoot position" factor tended to disappear, affecting significantly ( $P = 0.02$ ) only the root score in the third generation - order 4 produced the lowest score. Simultaneously, the clonal plant material regenerated became more homogeneous, exhibiting increasing similarities with juvenile seedlings in regard to morphological characteristics or organogenic capacity - potential to produce axillary shoots after pinching, ability for adventitious rooting -, and growth pattern - strictly orthotropic vigorous extending shoots.

In other words, the quality of the clonal offsprings obtained, in terms of true-to-type fidelity and in absence of intra-clonal variation, appeared good enough for use in clonal plantations.

2. Concomitantly, as the potential for adventitious rooting increased and the delays to root diminished - reduced to one month or even less -, the cuttings were observed to become less sensitive to the auxinic treatment, which had proved to have so strong a beneficial effect for the first generation.

As an illustration, data in Table 2 demonstrate the ineffectiveness of treating with auxin cuttings collected from the second generation of stock plants after the third and the fourth pinching operations.

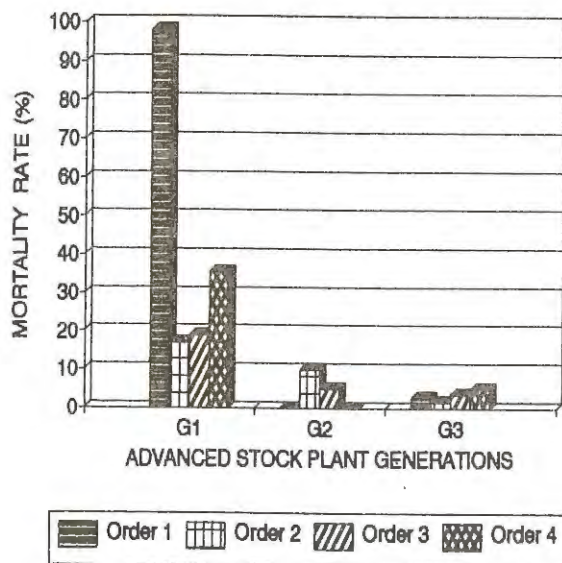


**Table 2. Auxin (Mixture) treatment effect on the ability for adventitious rooting: rooting rates of *Octomeles sumatrana* cuttings collected from the second generation of stock plants after they had been pinched 3 and 4 times.**

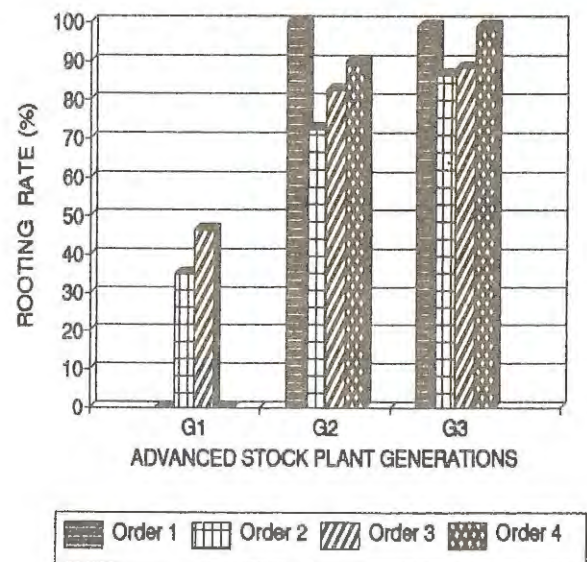
| CUTTING ORIGIN                                    | ROOTING RATES (%) |         |
|---|-------------------|---------|
|   | Auxin treated     | Control |
| 2nd generation of stock plants<br>pinched 3 times | 90.0              | 90.0    |
| 2nd generation of stock plants<br>pinched 4 times | 96.7              | 90.0    |

**Figures 4 a-c. Effects of the original within-shoot position of the cutting - defined as "order" (see text) - on adventitious rooting responsiveness relative to advanced generations of stock plants; G1 corresponds to the mobilization phase.**

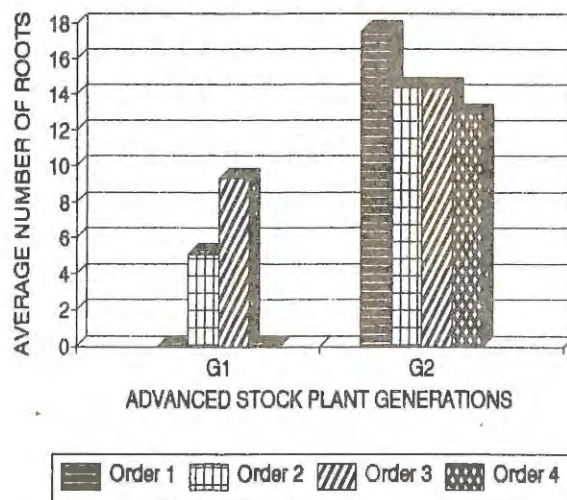
**4a. Effect on the mortality rate**



**4b. Effect on the rooting rate**



**4c. Effect on the average number of roots per rooted cutting**



Managing the stock plants strictly as defined in option 2 - only one cutting collection for each generation of stock plant - resulted also in enhanced ability of the mature selected genotypes for adventitious rooting as the number of successive propagation cycles - stock plant generations - increased, as illustrated in Fig. 5.

Conjointly, up to the third generation, the plant material became more responsive to auxin treatments ( $P < 0.01$ ) enabling to reach 90 to 100 percent of rooted cuttings as against 70 percent for the control (G3), without so much difference regarding the nature of the preparation used. In addition, up to that stage, the auxinic treatments were found to increase greatly the average number of primary roots per rooted cutting and the root score.

Thus, it appears obviously from the reported data that the manipulations applied to the mature selected plant material improved remarkably its overall potential to be propagated through rooted cuttings, reaching already levels sufficient for large-scale propagation.

## 5. DISCUSSION

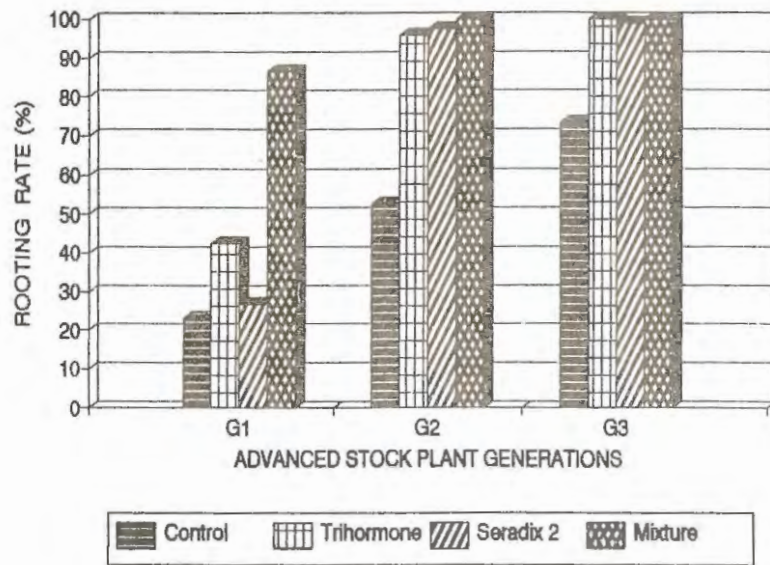
The advantages of clonal forestry are widely recognized (Libby and Rauter 1984). In practice, however, the magnitude of its application remains limited by the consequences of the maturation process affecting the selected genotypes with increasing time. In fact, the time period required to assess properly the worth of a genotype acts negatively on its potential to be propagated true-to-type by rooting cuttings (Franclet 1985, Hackett 1985, Wareing 1987, Pierik 1990). This is the reason why attempting to clone mature "Plus" trees selected in the wild remains so hazardous in most cases. Tree species susceptible to sprout from their base naturally or after felling have been observed to display generally better potential for vegetative propagation. *Octomeles sumatrana*, *Anthocephalus chinensis* and *Endospermum peltatum* fall into this category.

The necessity to cut down the ortet to promote stump sprouting carries the risk however of losing the genotype if it fails to sprout. A safety measure to secure the mobilization phase of really superior ortets should consist in grafting ramets collected from the crown onto same species young seedlings or rooted cuttings - in case of shortage of seedlings - used as rootstocks.

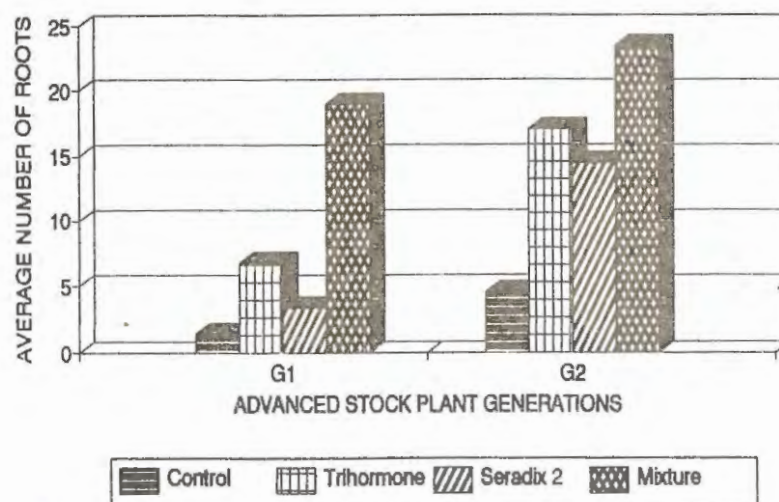


**Figures 5 a-b. Effects of different auxin treatments (see text for relevant information) on adventitious rooting ability of cuttings coming from successive generations of stock plants; G1 corresponds to the mobilization phase.**

**5a. Effect on the rooting rate**



**5b. Effect on the average number of of roots per rooted cutting**



The stage of development of the sprouting shoots utilized to make the cuttings was found to have a major influence on the capacity for adventitious rooting of the plant material. This could account for the fact that the terminal shoots of *Octomeles sumatrana* and *Endospermum peltatum* displayed an inability to root, by contrast with *Anthocephalus chinensis*. Similar observations were made on hybrids of eucalypts in Congo where too vigorous shoots produced by the stumps exhibiting anthocyanin stem pigmentation failed to root. This could be interpreted in terms of excess of vigour from the stump speeding up the differentiation process in the sprouting shoots and leading soon to the elaboration of new axes prematurely hierarchized giving rise to topophytic effects (Olesen 1978) and increasing the "C-effects" (Haissig and Riemenschneider 1988). The expected rejuvenation (Hackett 1985, Greenwood 1987) seems then to be quite space-time restricted to the early events of the sprouting shoot process. An interesting line of research would investigate the inner origin of these stump-produced shoots, and the influence of the mature tissues they emerged from on their physiological status.

Such observations supported anyhow the position of people arguing for the well-founded to distinguish between rejuvenation and "re-invigoration" (Hackett 1985, Wareing 1987, Pierik 1990).

On the other hand, manipulating the vegetatively mobilized resource by applying serial propagation methods resulted in improved capacity for adventitious rooting of the mature selected genotypes, in the same way it has been reported for other species (Monteuuis *et al.* 1987). Such procedures strengthen the presumption in favour of the beneficial effect of the newly formed adventitious root system in view of rejuvenating the propagated clones, maybe through the involvement of root-produced cytokinins (Greenwood 1987). In fact, it is interesting to note that the manipulations used to produce less differentiated plant material, with a certain balance between shoots and roots, limiting artificially a too large expansion of the shoot system and enhancing therefore the root system influence. Such practices are consistent with Borchert's (1976) interpretation of the maturation process in terms of correlative systems, emphasizing the beneficial effects of roots in supplying shoots with physiologically important metabolites and endogenous substances. However, some of these, like endogenous auxins, are assumed to be produced at the shoot tip level (Chaussat and Courduroux 1980), which may explain the better ability for adventitious rooting of the terminal shoot cuttings as compared to the single-node ones, as hypothesized also by Hartmann *et al.* (1990).

## 6. CONCLUSIONS

The results of these first investigations aiming to assess the possibility to propagate through rooted cuttings mature selected genotypes of *Octomeles sumatrana*, *Anthocephalus chinensis* and *Endospermum peltatum* with a view of clonal plantations are quite encouraging. The decisive role of the vegetative propagation techniques to take concretely advantage of the theoretical expectations has been once more demonstrated. The experiments in that field are continuing to confirm certain trends for a better performance.

Meanwhile, proper superior genotypes must be accurately selected, in order to be ready to start large-scale operations.

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FIGURE 1. *Octomeles sumatrana*





FIGURE 2. *Anthocephalus chinensis*



FIGURE 3. *Endospermum peltatum*



FIGURE 4. Clonal plantation of *Octomeles sumatrana*.